

2016 Conference for Clean Air Through Energy Efficiency

Overview of Energy from Landfill Gas in Texas

THINK GREEN.®



Landfill Gas: A Renewable Resource

- Natural anaerobic decomposition of organic waste in the landfill
- Recognized by U.S. EPA and many states as renewable resource
- Landfill gas is about 50% methane, the fossil fuel component of natural gas

Any application or
technology
that uses natural gas
can also use landfill gas
which is appropriately
processed



Landfill Gas Collection



< Perforated pipe wells are drilled into the waste, about one every acre



< The wells are connected to a header pipe. A blower places a vacuum on the header pipe to withdraw the gas.



< If it is not used as fuel, the gas is destructed in a flare

Landfill Gas Well Drilling



Gas Well installation in Final Cap



Environmental Protection is First Priority

Regulations for collection and control of landfill gas:

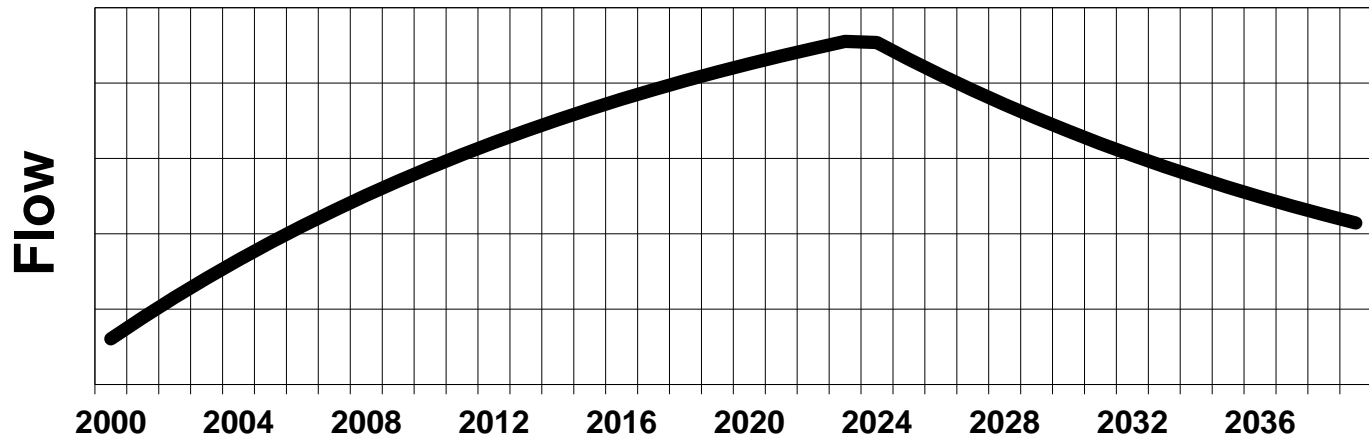
- Off-Site Underground Migration (RCRA Subtitle D)
- Groundwater Contamination (RCRA Subtitle D)
- Odor control
- Organic Carbon Emissions through cap (CAA - NSPS)

**The use of landfill gas for renewable energy
must not interfere with
regulatory compliance and environmental protection**

Production of Landfill Gas

- Percentage of organic waste
- Waste age
- Tons of waste already in place
- Rate of waste disposal (tons per year)
- Access to moisture

LFG flow will increase until landfill is closed, then decline.



Common Types of Landfill Gas Projects

Power -

On-site power plant using LFG as fuel, with electricity delivered to nearby utility distribution line, or LFG delivered to off-site utility or co-gen plant

Medium Btu -

LFG is delivered in dedicated pipeline to a single industrial or commercial user to offset fossil fuel for boilers, kilns, burners, greenhouses, etc. May also be used on-site for evaporation of landfill leachate.

High Btu, or Renewable Natural Gas -

Cleaned to pipeline-quality natural gas specifications, then compressed and delivered into a common carrier natural gas pipeline. May also be used at on-site CNG fueling station.

Landfill Gas Project Inventory

Type of Project	US	Texas
Power	450+	18
Medium BTU	110+	3
Renewable Natural Gas	40+	5
Totals	600+	26

Source: US EPA Landfill Methane Outreach Program database of operational LFG projects as of 12/14/2016; WM internal database; and personal knowledge

LFGTE in the Renewable Energy Portfolio

Drawbacks

Total resource is finite

Individual plant size is 1 MW to 10 MW

Advantages

Distributed energy: connected to distribution lines

Transmission cost: may reduce utility transmission costs

Base load resource: capacity factor is typically >90%

Peak load: produces power when it is needed the most

Revenue sources for LFGTE

Energy Sales

Market price, tariff rate, negotiated price, winning bid price into RFP

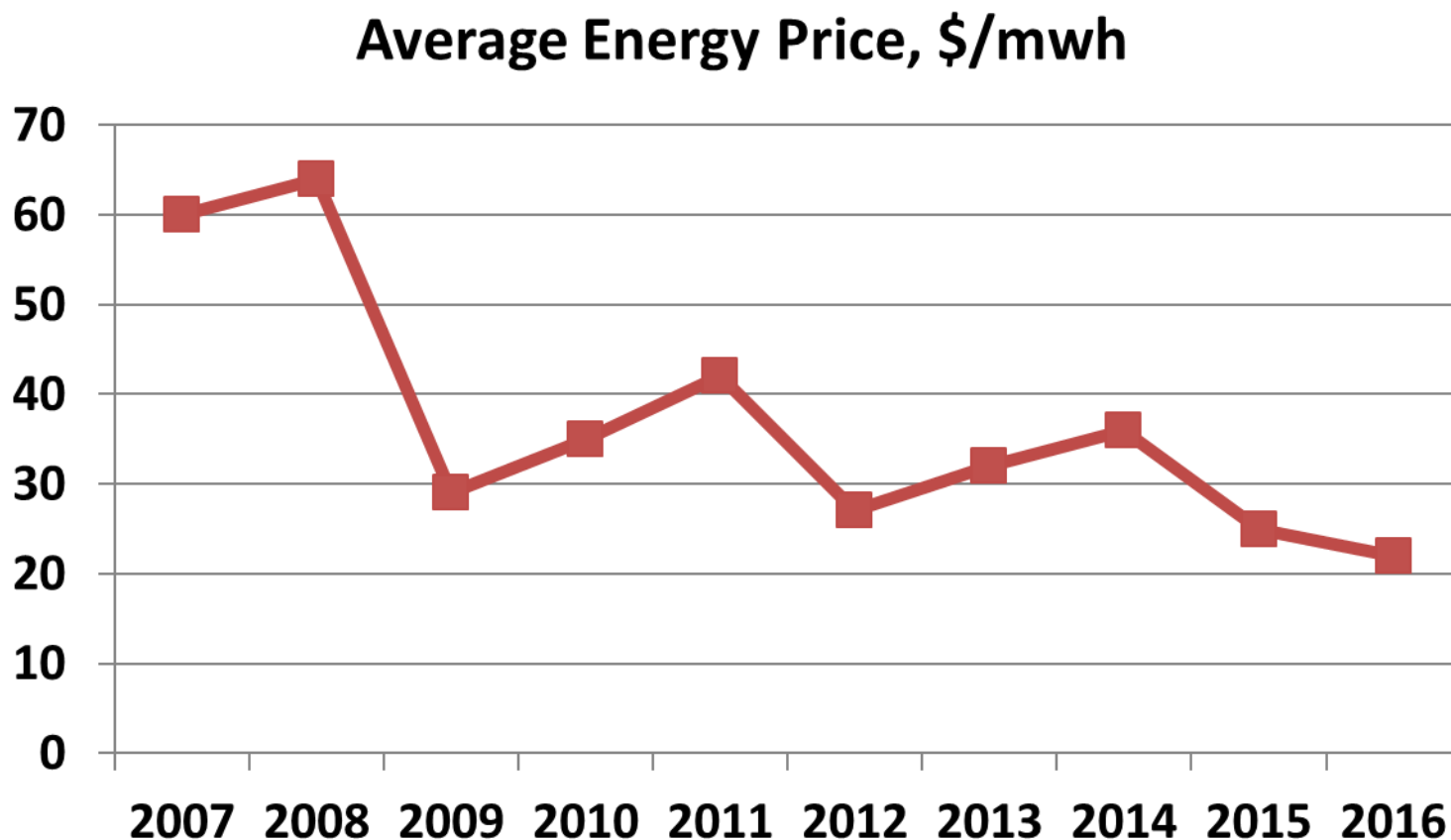
Renewable Energy Credits

- 29 states have Renewable Portfolio Standards
- One plant may qualify for multiple state RPS programs
- **RECs in Texas are \$0.50/mwh**
- NEPOOL = \$25 to >\$50, PJM = \$10 to \$20, Non-RPS states = \$0
- Some utilities bundle the energy and RECs at fixed price

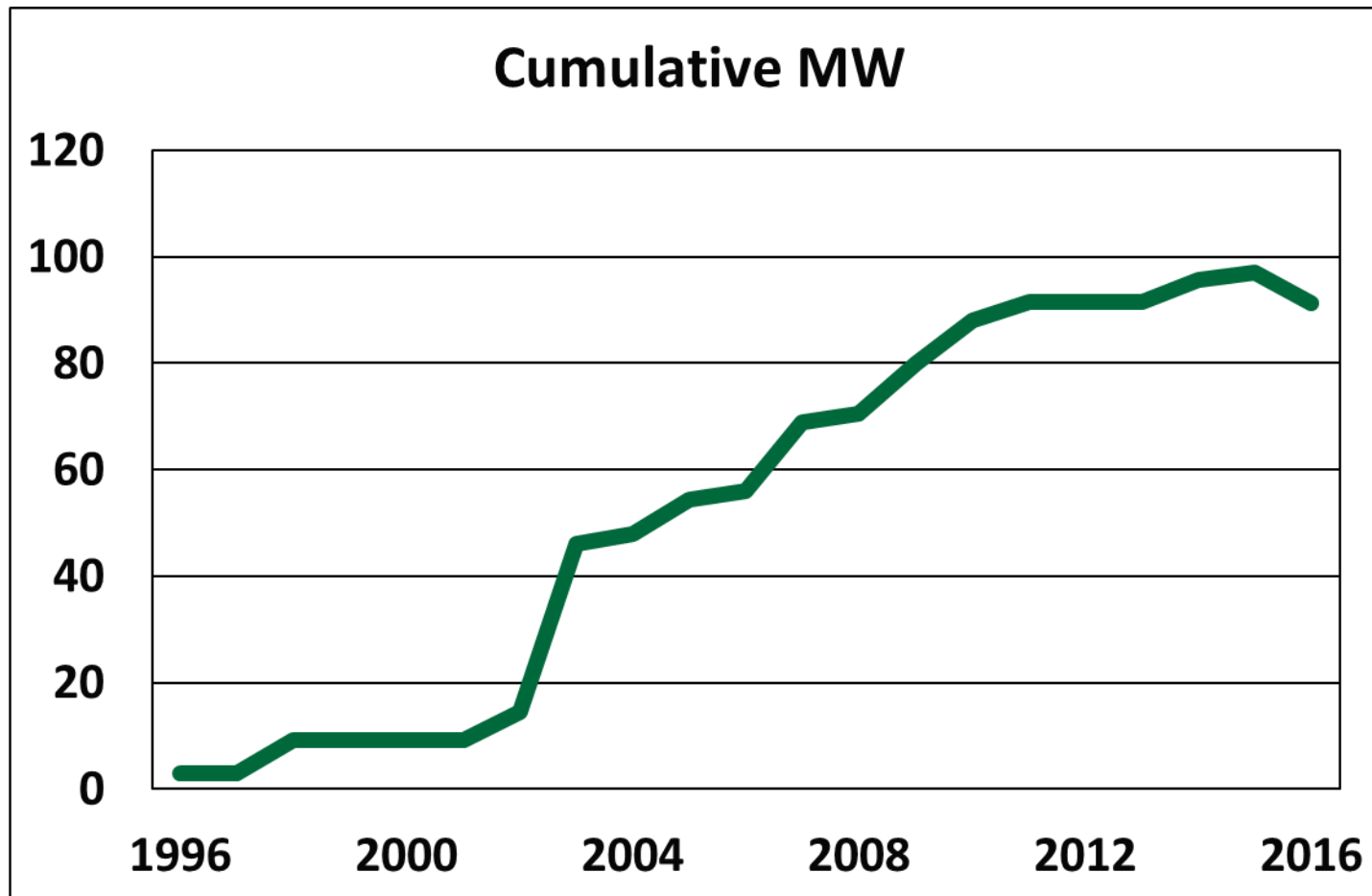
Federal Section 45 Production Tax Credits

- \$12/mwh for 10 years for landfill gas
- Must commence construction by end of 2016 to qualify for 100%

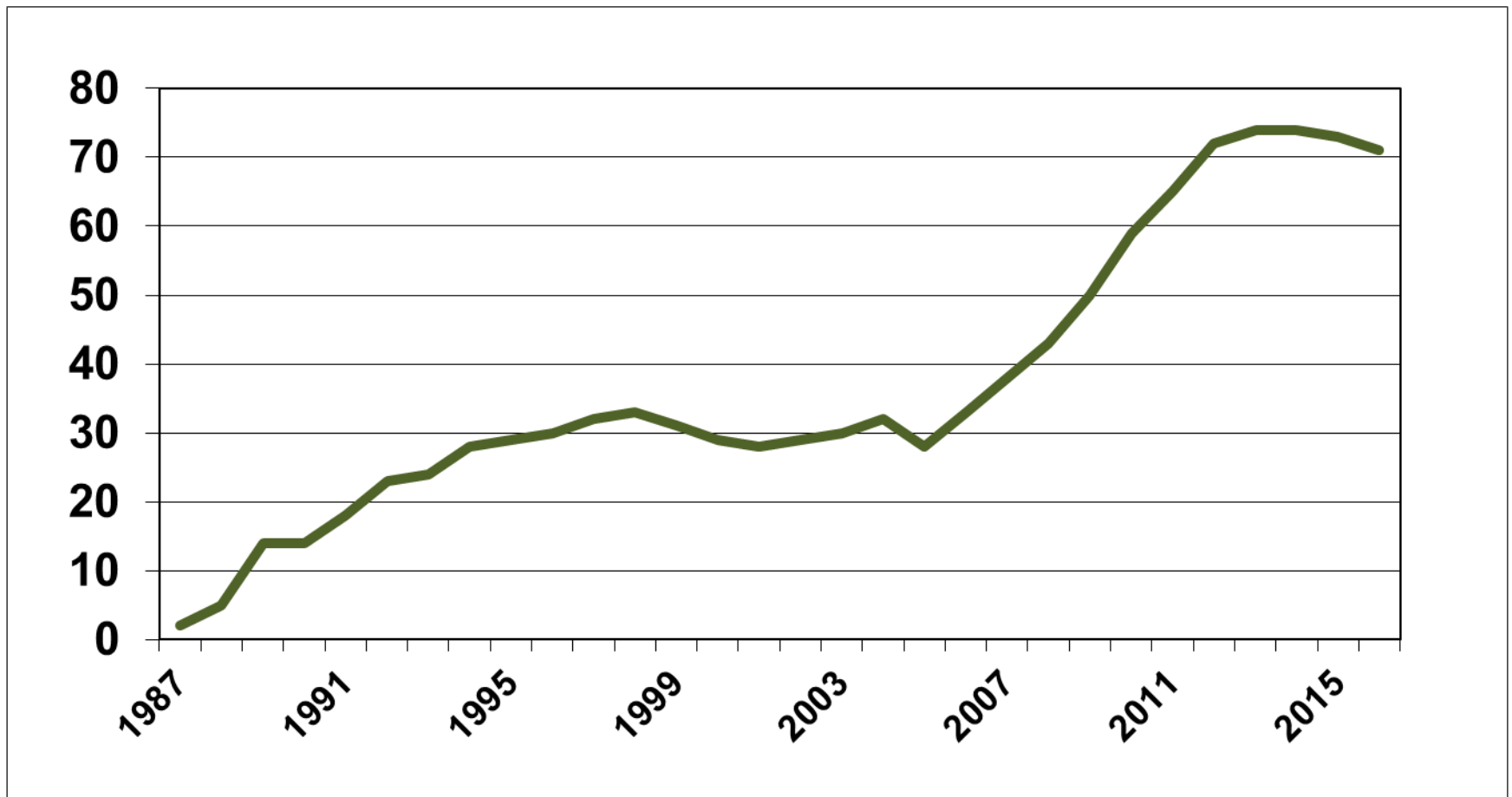
ERCOT Market Price History



Texas LFGTE Development History



WM Renewable Energy - LFGTE Plants in U.S.



LFG Industry Redirection

- Focus on production efficiency, landfill gas collection, and operating costs of existing LFGTE plants
- Continue to seek and market LFGTE opportunities in challenging market
- Organics diversion opportunities
- Renewable Natural Gas: landfill gas is classified as cellulosic biofuel by the EPA under the U.S. Renewable Fuel Standard
- New technologies

Renewable Energy Plant



Fuel Skid

Compresses, filters, and dewateres the gas



Engine Room

WM uses 1,070 Hp or 2,140 Hp Engines



Switch gear converts electricity to utility specifications



Radiators and Engine Exhaust Stacks



Transformer converts power to utility line voltage



Transmission line delivers power to utility



Renewable Energy Plant

